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PENSOFT

The presence of Dry Forest Racer, *Masticophis mentovarius* (Duméril, Bibron & Duméril, 1854) (Squamata, Colubridae), in the Cloud Forest of Monteverde, Costa Rica

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Abstract

Masticophis mentovarius (Duméril, Bibron & Duméril, 1854) occurs at low and moderate elevations in Lowland Dry Forest and Premontane Moist Forest. This species is known in Costa Rica mainly from the dry lowlands of the northwest. Here we report the presence of *M. mentovarius* at the Tropical Cloud Forest of Monteverde, Costa Rica, at 1275 m a.s.l. The new records provide information on the true limits of the distribution of species and may represent expansion of the species' range due to environmental changes caused by global climate change.

Keywords

Climate change, Neotropical Coachwhip, Premontane Wet Forest, reptile, snake, Tilarán mountain range

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Introduction

Despite its relatively small area (51,100 km^2), Costa Rica reports a rich fauna of reptiles (Rovito et al. 2015). The country is home to no fewer than 245 species of reptiles (Leenders 2019). Although this group of vertebrates is relatively well known in Costa Rica, an increase in knowledge since the publication of the comprehensive coverage by Savage (2002) has included the discovery of new species, establishment of new country records, and recognition of taxa resurrected from synonymy (Savage and Bolaños 2009). Additionally, new distributional records of reptile species have been continuously published, showing that there is still much more to learn about these animals in Costa Rica (e.g., Abarca and Ray 2021; Nuñez Escalante et al. 2021a, 2021b).

There are at least 141 species of snakes in Costa Rica (Leenders 2019), some with wide distributions and others

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restricted to just the Caribbean slope, Pacific slope, or highlands (Solórzano 2004). Several species have become rare due to factors such as habitat destruction and fragmentation that affect the rest of the biodiversity (Cardinale et al. 2020). There are several misbelief about their biology, such as the popular misconception that all snakes are venomous, so all of them have to be killed (Solórzano 2003). Another threat to snakes in Costa Rica is global climate change that affects biodiversity in general (IPCC 2002). Several Costa Rican vertebrate species have been forced to transition their distributions to higher elevations (Mora et al. 2021), and several snake species have declined or disappeared from some Neotropical communities (Zipkin et al. 2020). As a result, new information about distribution limits of species is very important. New locations provide information on the true limits of the distribution of species. Knowledge of species' distribution is fundamental for understanding their ecology and biogeography (Solís et al. 2021). In other cases, however, what is being reported for new locations could be because of changes in the habitat due to anthropic factors or environmental changes caused by global climate change (Mora and López 2014). Climatic changes have influence trends in biodiversity and changes in elevational distributions (Brown 2001; Mora et al. 2021). Consequently, it is necessary to consider changing global climate regimes to understand how they affect all types of biological systems, from individuals to whole ecosystems (Kontopoulos et al. 2020). Currently, distributional changes of animal and plant species is a matter of great concern for biodiversity conservation (Mora and López 2014; Mora et al. 2021).

Dry Forest Racer *Masticophis mentovarius* (Duméril, Bibron & Duméril, 1854), is a large, fast-moving diurnal snake found in open areas such as pastures and roadsides and thickets in Lowland Dry Forest and Premontane Moist Forest and marginally in Premontane Wet Forest (Savage 2002) from near sea level to 450 m (Leenders 2019). *Masticophis mentovarius is* terrestrially active during the early part of the day, and it occasionally climbs onto low vegetation to rest or in search of prey (Campbell 1998; Savage 2002). It feeds on lizards, snakes, frogs, birds, bird eggs, mammals, and even fish (Bello-Sánchez et al. 2016). Although the distribution of this snake appears spotty and apparently discontinuous (Knight et al. 2016), it appears to prefer hot, dry terrain of the drier lowlands of Mesoamerica and adjacent slopes from Sonora, Mexico, to northwestern Costa Rica, and also on the Yucatán Peninsula, Mexico, and other isolated, dry habitats on the Atlantic slope of Central America, as well as in Colombia and Venezuela (Savage 2002). This species is known in Costa Rica from the dry lowlands of the northwest, with some records from the Central Valley (Solórzano 2004). Although there is a record from the Tilarán Mountain Range, it is from 440 m a.s.l. in the Tropical Dry Forest. Pounds and Fogden (2000) considered this snake species present on the Pacific slope of the Monteverde region, also in the Tilarán Mountain Range, although they provided no altitudinal data. Here, we report the presence of *M. mentovarius* in the Cloud Forest of Monteverde at 1275 m elevation.

Methods

We conduct occasional reptile surveys at Monteverde, Puntarenas, Costa Rica, mainly to document species' localities in the area and to take photographs. Monteverde is a well-known area for ecotourism in Costa Rica (Nadkarni and Wheelwright 2000). The area has attracted a large number of researchers who have greatly contributed to the knowledge of the region's biodiversity (Nadkarni and Wheelwright 2000). The Monteverde Biological Reserve has a unique position on the continental divide, where the cloud forest offers a variety of microclimates. The nearby villages of Monteverde and Santa Elena are located in the Tropical Montane Cloud Forest, a relatively narrow elevational zone with frequent cloud cover during much of the year (Nadkarni and Wheelwright 2000). The Monteverde vegetation is an evergreen forest with a few deciduous species, especially on the Pacific slope, with moderate epiphyte diversity and abundance (Haber 2000).

As a result of a hike on a trail in the Los Llanos community, Santa Elena, we found a *M. mentovarius* at the side of the forest. We took photographs and recorded the main visible traits of the individual to provide a preliminary identification. We then allowed it to continue its daily activities. This species has not been reported previously from the Cloud Forest of Monteverde, specifically from the Premontane Wet Forest (forest nomenclature according to the life zone system by Holdridge 1967).

We obtained occurrence data for *M. mentovarius* from literature (Savage 2002; Solorzano 2004; McCranie 2011; Leenders 2019). We initially identified the snake species in situ and then confirmed it by comparing our photographs with similar specimens and by a literature review (Savage 2002; Solorzano 2004; McCranie 2011; Leenders 2019). We reviewed nine specimens of *M. mentovarius* from the Zoology Museum of the University of Costa Rica (UCR) for comparison and confirmation of our specimen's identity. Our identification was verified by Gerardo Chaves, curator of herpetology at the UCR. In addition, we reviewed records for this species in Costa Rica in the Global Biodiversity Information Facility (GBIF 2021).

Results

Masticophis mentovarius (Duméril, Bibron & Duméril, 1854)

New record. COSTA RICA • Puntarenas, Cordillera de Tilarán, Monteverde, Los Llanos de Santa Elena; 10°18′17″ N, 084°50′04″W; 1275 m elev.; 07.III.2021; Steven Gallo Gutiérrez & Jerson Santamaría leg.; 1 adult, sex undetermined (Fig. 1); individual photographed but not collected.

Figure 1. *Masticophis mentovarius* at Los Llanos de Santa Elena, Monteverde, at 1275 m elevation, Puntarenas, Costa Rica. Photo by JASM.

Comments. The specimen of *M. mentovarius* was found in the understory of thicket (Fig. 2). The snake was at the side of a trail, where it was sitting, basking, quiet, and calm (Fig. 1).

Other data records examined. Individuals of *M. mentovarius*, from several localities within the dry forest of northwestern Costa Rica and some localities at the Central Valley (Fig. 3), are held in the UCR collection. Elevational extremes for records in this collection are 960 m and 1080 m from San Rafael de Escazú (UCR 13922 and UCR 7213, respectively). There are two localities from Atenas and San Rafael, Alajuela, on the Central Valley (UCR 15543 and UCR 15600 at 500 m elevation, and UCR 6150 at 840 m). All other localities (16) are from the dry northwest from localities between 7 and 920 m a.s.l. There are 45 records for this species in the GBIF database from Costa Rica; most of them are from the dry northwestern lowlands (GBIF 2021). However, only one entry gives elevation. This record is listed as from San José at 335 m a.s.l., but it actually must be from Puntarenas province (the record is "44 miles north of San Jose"; GBIF 2021). One record at the Central Valley is from Alajuela but at approximately 800 m elevation. Another record is from Santa Ana in San José and must be around 850 m elevation, similar to UCR records from Escazú, San José. A record from Cartago at approximately 2500 m elevation (09°41′50″ N, 083°54′39″W; GBIF 2021) seems to be a mistake. This record (LACM 103876), as provided by Johnson (1977), may have led Cupul-Magaña et al. (2016) to state that *M. mentovarius* is distributed from sea level to 2500 m elevation, or they may have been referring to Wilson and Johnson (2010), who also stated the same maximum elevation for this species.

Figure 2. Understory and thicket vegetation where *Masticophis mentovarius* was found at Los Llanos de Santa Elena, Monteverde, Puntarenas, Costa Rica. Photo by SGG.

Other specimens examined. COSTA RICA • Guanacaste, La Cruz, La Cruz, Bellavista, 8 km south of La Cruz, route 1 (11°01′30″N, 085°38′20″W, 247 m), 28 September 1965 (UCR 149) • Guanacaste, Cañas, Bebedero, Taboga, Hda. Taboga (10°20′50′N, 085°10′30″W, 7 m), 5 February 1967 (UCR 964) • Puntarenas, Pitahaya, Cebadilla, bridge over Aranjuez River, route 1 (10°06′06″N, 084°48′40″W, 106 m), 18 March 1972

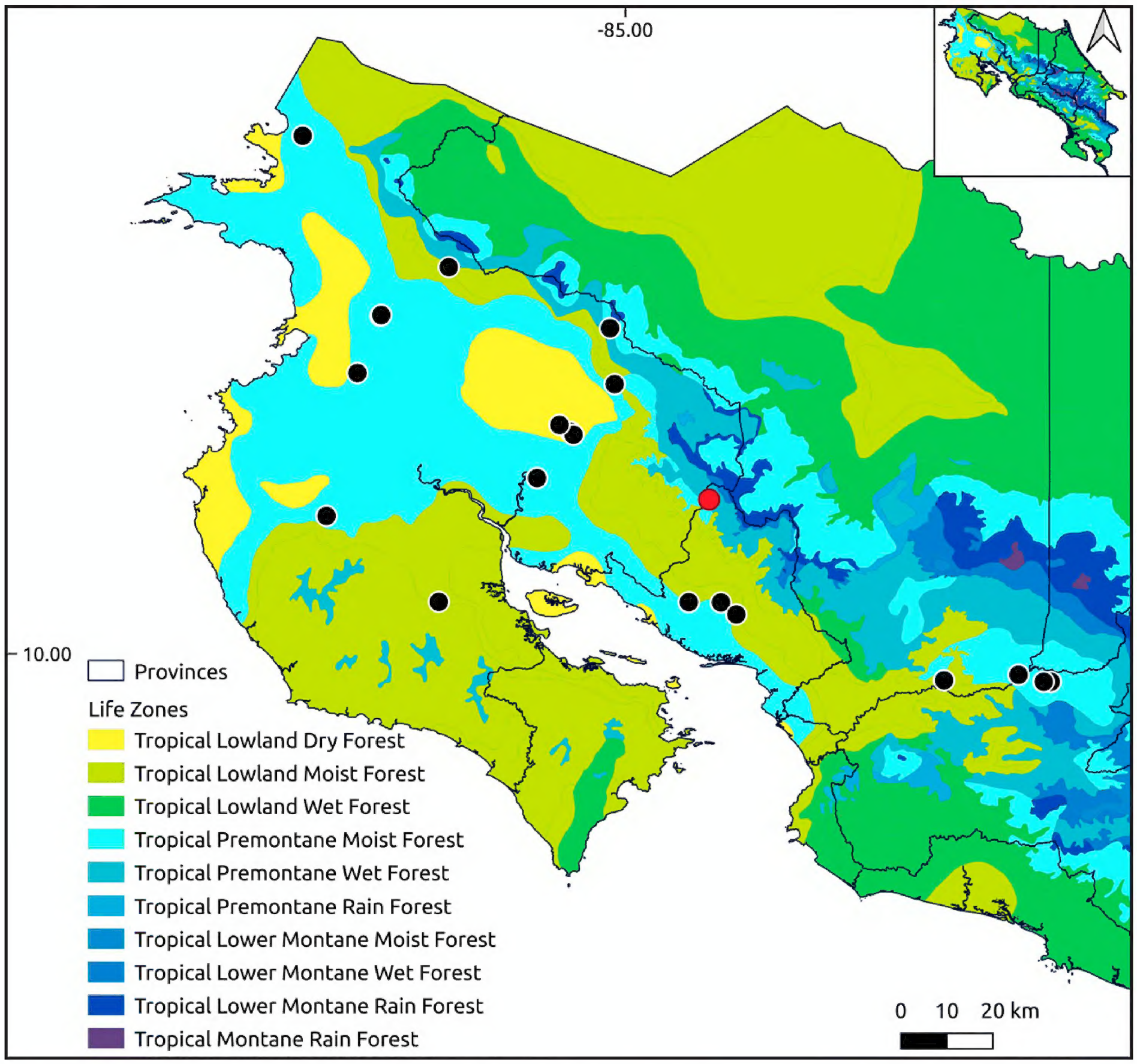

Figure 3. Life zones of northwestern Costa Rica with locations of specimens of *Masticophis mentovarius* deposited at the Museum of Zoology, University of Costa Rica (black dots). The red dot indicates a new locality at Los Llanos de Santa Elena, Monteverde, in the Premontane Wet Forest. Map by Gerardo Chaves.

(UCR 3632); Alajuela, San Rafael, Ojo de Agua, Reforma (09°56′40″N, 084°09′30″W, 840 m), 29 July 1975 (UCR 6150) • San José, Escazú, San Rafael, Guachipelín centro (09°56′50″N, 084°22′10″W, 1080 m), 17 July 1977 (UCR 7213) • Guanacaste, Cañas, Palmira, Agua Caliente, Agua Caliente creek (10°38′40″N, 085°01′50″W, 920 m) 11 December 1984 (UCR 9398) • Guanacaste, Nicoya, Mansión, Mansión Centro (10°06′10″N, 085°22′10″W, 87 m) 1 May 1985 (UCR 9618) • San José, Escazú, San Rafael, Guachipelín, 1 km W of Multiplaza (09°56′40″N, 084°10′20″W, 960 m), 3 July 1998 (UCR 13922) • Guanacaste, Tilarán, Santa Rosa, Ángeles, 1 km route 1 (10°32′01″N, 085°01′17″W, 440 m) 31 December 1999 (UCR 14605) • Alajuela, Atenas, Concepción, Cuesta Pan de Azúcar (10°09′55″N, 083°37′04″W, 500 m), 4 January 2001 (UCR 15543, UCR 15600).

Identification. Dorsal scales smooth, in 19–17–13 rows, with two apical pits; 181–205 ventral scales; 102–123 paired subcaudals; cloacal scute divided. Preoculars 2; postoculars 2; supralabials 6–8, with 1 or 2 bordering orbit; infralabials 5–11; temporals 1 + 2 to 3 + 4 (Johnson 1977). Enlarged, symmetrical plates on top of head 9. A sharp-edged ridge formed by scales lines the top of the eyes, which are large and with round pupils (Fig. 1). Head fairly large, but not much wider than neck (Leenders 2019). Total length can reach 250 cm (Leenders 2019), and the long tail is equal to 32–36% of the total length (Savage 2002). Dorsal color mostly dull brown, uniform pale or dark brown to yellowish brown or grayish brown (Solorzano 2004). Adult uniform or with a dark brown spot on each scale than tend to form narrow longitudinal dark stripes or indistinct, irregular dark, crossbands or stripes (Savage 2002). Venter immaculate pale yellow anteriorly turning to dark reddish or brown on posterior third of body and underside of tail (Savage 2002; Solórzano 2004). Specimens from Costa Rica are

gray-brown, lighter posteriorly, with spotting on the head and throat (Johnson 1977). This mottled pattern on the side of the head and commonly on the chin, throat, and anterior ventrals is characteristics of this species (Savage 2002; Muñoz and Johnston 2013). The spots on the side of head, together with the smooth dorsal scales, separates this snake from most other species in Costa Rica (Savage 2002). This is an easily distinguishable snake, and the individual reported here (Fig. 1) was identified with complete certainty.

Discussion

We report the presence of *Masticophis mentovarius* in the Tropical Cloud Forest of Monteverde, specifically in Premontane Wet Forest in the Tilarán Mountain Range (Costa Rica) at an elevation of 1275 m. There is some conflicting information on the elevational range of this species and the ecosystems it inhabits. It occurs at low and moderate elevations whenever it is present (McCranie 2011). The species has been found from about 50 to 990 m in the tropical Dry Forest, Subtropical Moist Forest, and Subtropical Dry Forest formations in Honduras (Wilson and Meyer 1985) and at 200 m elevation in Tropical Dry Forest and Dry Premontane Forest with an average temperature of 27 °C in Panamá (Pérez Santos 1999). In Guatemala, the species occurs from near sea level to about 1400 m (Campbell 1998). However, Renfijo et al. (2015) stated that this snake reaches 2200 m elevation. In Wilson et al.'s (2010) monumental treatise of the Mesoamerican herpetofauna, Wilson and Johnson (2010) pointed out that *M. mentovarius* is found in the isthmian Central America highlands (and other mountainous systems) up to 2500 m a.s.l. Based on this, *M. mentovarius* inhabits not only the Premontane Forest, but also the Lower Montane Forest (both, Lower Montane Wet Forest and Lower Montane Dry Forest; Wilson and Johnson 2010).

This species has been assumed to occur in the lowlands of Costa Rica to 450 m elevation (Leenders 2019). However, Savage (2002) pointed out that this species reaches 1435 m in the Central Valley. The two highest elevations known for UCR specimens are 960 and 1080 m. However, Solórzano (2004) pointed out that the species reaches up to 1400 m elevation in Costa Rica. Nevertheless, these areas are southeast of the northwest dry forest, and they are transitional habitats of the central part of the Pacific lowlands and areas adjacent to the Central Valley. Several reptile species from the dry forest of northwestern Costa Rica have a similar pattern of distribution into the Central Valley (Leenders 2019).

The new locality of Los Llanos de Santa Elena is located in the Tilarán Mountain Range of northcentral Costa Rica, and it is in the middle of the Tropical Montane Cloud Forest (Nadkarni and Wheelwright 2000). Our new locality is at 1275 m in the Premontane Wet forest. Savage (2002) pointed out that *M. mentovarius* can be found marginally in this life zone, and even if some records we reviewed may be from this ecosystem, none is as high as 1275 m a.s.l. Reports of *M. mentovarius* occurring over 2000 m (Johnson 1982) and up to 2500 m (Wilson and Johnson 2010) seem not to referring to Costa Rica (except possibility LACM 103876, as already mentioned).

Monteverde biodiversity is well known because of the continuous presence of researchers and visitors interested in nature (Nadkarni and Wheelwright 2000), and there are two herpetariums and several experienced and knowledgeable collaborators on the country's snakes. It is unlikely that *M. mentovarius* has gone unnoticed, so we believe this is a recent arrival in Los Llanos de Santa Elena. However, this species is really fast moving, so it may have been overlooked, and it is not common anywhere. We observed only one individual, there is the possibility that this individual represents an accidental introduction. It could have hitched a ride on a vehicle, or it may have escaped from a herpetology exhibition, and the owner may prefer to stay silent to avoid any consequences.

On the other hand, the presence of this snake in Los Llanos de Santa Elena may be the result of increasing temperatures resulting from climate change, a phenomenon that has forced several Costa Rican vertebrate species to move their altitudinal ranges upwards to higher elevations (Pounds et al. 1999; Mora et al. 2021), mainly in Monteverde (Pounds et al. 2005). With climate change, there has been a general trend for species' distributions to move towards the poles and to shift upwards in elevation (IPCC 2007; Chen et al. 2011; Rowe et al. 2015). In Monteverde, many premontane breeding birds have invaded lower-montane habitats, whereas some lower-montane species have retreated up to the mountain slopes (Pounds 2000). The reptile community of Monteverde also has been affected, and there is evidence that reptile diversity has declined with the disappearance of several species (Pounds 2000). The decline of amphibian populations at some Neotropical habitats has negatively impacted snake communities in some areas, with some species disappearing (Zipkin 2020). Nevertheless, climate change may be provoking the arrival of lower distribution species, such as de Dry Forest Racer to the Cloud Forest of Monteverde. Changes in the distribution of some animals will cause other impacts, some of which are predictable. Several species will come into contact with others with which they did not have it. These contacts may cause displacement effects due to competition, hybridization, nest parasitism, the promotion of infectious diseases and others that could be a threat to several endemic or threatened species (Pounds et al. 1999).

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Authors' Contributions

Conceptualization: SGG. Investigation: JASM. Methodology: LIL. Writing – original draft: JMM. Writing – review and editing: JASM, LIL, JMM, SGG.

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